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ABSTRACT

The Zimbabwe Secondary School Science Project (ZIM-SCI) developed student study guides, corresponding teaching guides, and science kits for a low-cost science course which could be taught during the first 2 years of secondary school without the aid of qualified teachers and conventional laboratories. This teaching guide, designed to be used in conjunction with the related student guide, provides instructional strategies, lists of required materials, laboratory procedures, and other information for activities and experiments in a unit dealing with: (1) the generation of electricity; (2) uses of electricity in everyday life; and (3) safety precautions when using electricity in the home and in commerce and industry. Major areas investigated include: work and electrical power; changing electrical energy into other forms of energy; magnetic fields due to adjacent permanent magnets; the motor effect of an electric current; electromagnetic induction and generators; precautions related to using household electricity; and paying for electrical power. Each section in this guide corresponds to a given section in the student study guide. (JN)

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TEACHERS GUIDE UNIT 12

USING ELECTRICITY

UNIVERSITY OF ZIMBABWE
AND MINISTRY OF EDUCATION AND CULTURE

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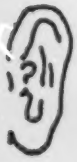
The following symbols will be used to indicate the points in the lesson at which teacher activity is particularly important. These symbols also appear at the corresponding points in the pupil study guides.

Practical work. The necessary instructions for each experiment will be given to you when you see this symbol.

Written exercises for the pupils. If possible these should be put on the blackboard before practical work begins so that the pupils can see what to look for.



Teacher information. The pupils will need extra guidance at these points. The information they will need from you is given where you see this symbol.

This symbol appears at a point where it is necessary for pupils to think over what they have done in the past few lessons. Set aside a period for this review activity. Encourage the pupils to read over their notes and the study guide section which they have just covered. It may be helpful to ask them to write a summary too.

The following symbols which appear only in the Teacher's Guide are used to indicate important points for you the teacher.

Take note of an important point.

This symbol indicates a preparation of apparatus which should be done well ahead of time. Please read these notes carefully and carry out the instructions well in advance.

We have placed this symbol next to experiments where we feel there may be a possible danger. Please read the section carefully so that you know about the particular danger in that experiment. It would also be wise to refresh your memory on the appropriate safety or first-aid procedures described in the Zim-Sci Handbook.

This symbol appears next to activities which are not experiments but involve pupils in observation and perhaps collecting information. An example is the field trip.

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SEPTEMBER 1983

AIMS OF THIS UNIT

ELECTRICITY

At the end of this section pupils will be able to:-

(i) distinguish between conductors and insulators.

(ii) identify and draw a simple D.C circuit, including a switch.

(iii) distinguish between current as a flow of electricity and voltage as the measure of its ability to do work.

(iv) explain resistance by analogy with friction.

(v) distinguish practically between series and parallel circuits.

(vi) demonstrate how current voltage and power can be measured in simple circuits, and read a household electricity meter.

(vii) explain the relationship between current, voltage and resistance.

(viii) design simple experiments to observe heating and lighting effects of electricity.

(ix) explain the use of fuses, and why it is dangerous to overload any circuit.

(x) demonstrate how to wire a three pin plug and explain the function of the earth wire.

(xi) state the relationship between power, energy and time so as to have a basis for calculating electricity costs.

(xii) Interpret simple household circuit diagrams.

(xiii) explain that an electric current has a magnetic effect.

(xiv) describe how electricity can result from energy conversions and vice versa.

These aims are for both Units I_1 and I_2 on electricity. The aims in the Study Guide have been simplified and augmented for easy understanding by the pupils. They are basically the same as the ones above.

N.B. This Unit has been written to cover the encircled numbers of the Aims above.

CONCEPT DEVELOPMENT

INTRODUCTION

Unit I1 dealt mainly with the basic concepts of Current, Voltage and Resistance. Unit I2 deals with the generation of electricity and its uses in everyday life. It also deals with the Safety Precautions which must be observed when using electricity in the home and in commerce and industry.

WORK AND POWER

Unit H1 on Forces in Action deals with mechanical work and power. In this Unit, a few numerical examples are used as re-inforcement of work, power. This is followed by electrical power. Again numerical examples are used to put the concepts across. Power ratings of electrical appliances are worked out, discussed and numerical problems on electrical power are given as an exercise.

CHANGING ELECTRICAL ENERGY INTO OTHER FORMS

Electrical energy can be converted into other forms of energy. Students investigate the heating, lighting and magnetic effect of electrical energy. (Note that chemical effect was met earlier in Unit F.)

MAGNETIC FIELD DUE TO ADJACENT PERMANENT MAGNETS

Experiments with small magnets and iron filings are carried out to show the magnetic field due to two unlike and like poles of adjacent magnets.

THE MOTOR EFFECT OF AN ELECTRIC CURRENT

An experiment is carried out to show that a moveable conductor (loop) through which electricity passes moves in a definite direction when placed in a magnetic field. This leads to the construction of a simple electric motor. The uses of electric motors in every-day life are discussed. Special mention is made on the electrification of the National Railways of Zimbabwe and students are forewarned about the inherent dangers associated with the electrification.

ELECTROMAGNETIC INDUCTION - THE GENERATOR

A factory-made electric motor model is used to generate electricity. The coil is moved mechanically and an electric current is recorded by an ammeter connected to the generator. Through Activities, students learn to generate DC and AC using an electric motor and a bicycle dynamo. Graphical representation of the movement of the ammeter pointer for both DC and AC is introduced and this leads to the cycles in AC. The generation of electricity at Kariba and its distribution to various parts of the country is then discussed.

HOUSEHOLD ELECTRICITY

Household electricity is dangerous because it is at a much higher voltage which drives large currents through lighting and power circuits. To ensure that electricity used in the home is safe, certain safety precautions/ measures are taken and these are:

1. Fuses of correct current ratings are connected to the live conductor to protect the circuit and the appliances connected to it against overheating and starting a fire by blowing.

2. Switches are connected to the live conductor to prevent the appliances remaining 'live' when electricity is switched off. This protects the user against electric shocks should the appliance be touched.

3. Colour code is used to ensure that correct wiring is done.

4. Earthing is used in the power circuits to protect the user against electrical shocks in the event of using a faulty appliance.

PAYING FOR ELECTRICAL POWER

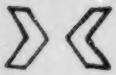
Electrical energy used in the home must be paid for. The amount to be paid depends upon the units (kWh) consumed. To work out the units consumed the students must know how to read the meter. The amount payable to the Electricity Supply Commission can then be calculated if the cost of a unit is known.

WORK

Page 1

Work was dealt with in Part 3 of Unit H1. This is mainly revision work. Emphasise the Joule (J) is the work (or energy involved) when a force of 1N moves its point of application 1 metre.

Summary



Ask your students to write down this in their notebooks.

POWER

Page 2

There are two illustrations which are the same, one for girls and the other for boys. Go over the example on Page 3 slowly with your students and then ask them to write down the definition, the equation of and the unit of mechanical power.

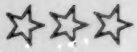
ELECTRICAL POWER

Page 4

Slowly go through the first two paragraphs with your students. They are the introduction to very important concepts.

We have established in I1 the concept of available electrical energy as the "voltage" of the electrical energy source. It is the volts which both causes a current to flow in a complete circuit, and provides the energy which the current carries. This is why we say: *the rate of delivery of energy is equal to the available energy multiplied by the rate of flow.*

i.e.



Joules/second = Watts = volts x amperes

rate of energy delivery = available energy x rate of flow of electricity.

POWER OF LIGHT BULBS

Page 5

Provide each group with a pair of bulbs for the Activity. Let them read the numbers marked on each bulb and then go through the worked examples to find the power and the current respectively. Draw the student's attention to the last sentence on this page. The current can always be calculated once power and p.d. are known. (See page 36.)

POWER APPLIANCES

Page 6

These are illustrations of some common power appliances used in modern homes. If your school is supplied with electricity and you have either a heater, an iron or kettle it will be a good idea to bring some to the class and ask the students to read the power rating and p.d.
Also instruct them to calculate the current.

EXERCISE 1 Page 7

ELECTRICAL POWER

1. An electric heater has a power rating of 1 000 W.
   How many joules of energy are produced when the heater is left on for 60 seconds?

2. An electric stove is marked 2415W 230V.
   Calculate the current that flows through the stove when it is switched on.

3. Write down the summary on Page 7.

ANSWERS

1. Power rating of 1 000 W = 1 000 J/s
   Energy produced in 60s = 1 000 x 60
   = 60 000J
   = 60 kJ

2. $\text{Amps} = \frac{\text{Watts}}{\text{Volts}}$

   $= \frac{2415}{230}$

   = 10,5 A

3. As per page 7 of S.G.

CHANGING ELECTRICAL ENERGY INTO OTHER FORMS Page 8

1. Lighting Effect: mainly revision.
   Emphasise that electrical bulbs are energy converters which change electrical energy into heat and light.

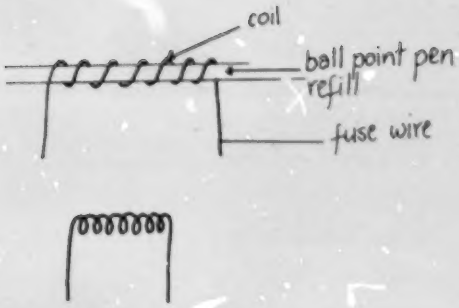
Charge the rechargeable cell fully before the demonstration.

2. Demonstration Experiment:

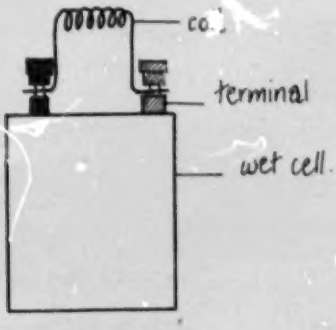
HEATING EFFECT OF ELECTRICAL ENERGY

You will need:

a 5 amp fuse wire (about 20 cm long)
a wet cell (rechargeable battery) fully charged
ball-point pen refill



Wind the fuse wire around a refill. Make about 5-8 turns. Remove refill and press ends of coil so that the coils are near each other.



Connect the coil to the battery. The coil should become red-hot very quickly so do not hold the coil with your bare fingers!

Ask the students the following questions.

What happens to the coil when it is connected to the wet cell?
Into which energy is electrical energy converted?
Is light energy produced?

Touch the coil with a piece of paper.
It should be charred or glow showing students that it is hot.
BREAK THE CIRCUIT AS SOON AS THE STUDENTS HAVE MADE THEIR OBSERVATIONS.

N.B.

1 The fuse wire has resistance because it is a <u>thin</u> wire. The energy conversion is caused by this resistance to the current.

Before the lesson cut the required length of the wire and put away the card

2 Ask pupils to bring iron nails (NOT STEEL NAILS OR SCREWS. These retain magnetism.)

Ask pupils how the energy conversion would change if the same length of wire was made "thinner" or if it was made "longer"?

ANSWER

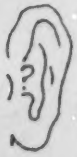
Thinner wire = more resistance in the same length so more energy converted, more heat, hotter wire perhaps causing it to melt.
Longer wire would also mean more resistance (and more heat) but it would be spread over a longer length so each cm of wire would not get as hot.

3. EXPERIMENT 1: MAGNETIC EFFECT OF ELECTRICAL ENERGY Page 9

For each group you will need:

a new cell
3 leads
an iron nail (not necessarily 5 cm)
iron filings
evaporating dish.

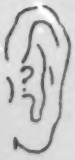
Let your students carry out the experiment as per S.G.
Remind them to break the circuit once the observations have been made since the circuit is a short circuit.



DISCUSSION Page 10

The nail does not become a magnet simply by winding a lead around. The nail only becomes a magnet when electricity flows through the coil. When the circuit is broken the nail loses almost all the magnetism.

For the discussion, point out that the coil becomes magnet when electricity passes through it. When a nail is included it makes the electro-magnet a powerful one.



DISCUSSION page 10

Both the motorcar and radio use electricity for their operation. Both, therefore, produce electromagnetism. That from the motorcar is more powerful than that of the radio. When electromagnetism is switched on and off or changed rapidly it causes "radio" energy. Hence the electromagnetism of motorcar interferes with the radio energy we receive from ZBC which results in poor reception.

SUMMARY Page 11

Ask your students to write down numbers 1 - 3 of the summary under the heading:
EFFECTS OF ELECTRICAL ENERGY.

PERMANENT MAGNETS: Page 11

EXPERIMENT 2: EFFECT OF ONE MAGNET ON ANOTHER. Page 11

Provide each pair of students with a pair of magnets.
Let them investigate the effect of one pole of a magnet on the other as per S.G.

Note: Some of the magnets we provide have a North pole with green paint and a South pole with red paint. What is important here is not the N or S poles but LIKE poles or sides (green-green or red-red) and UNLIKE poles (red-green).

EXERCISE 2: EFFECTS OF ELECTRICAL ENERGY AND PERMANENT MAGNETS

Page 12

1. Which electrical appliance converts electrical energy into:

   a) heat energy
   b) heat and light?

2. What is the name of the resistance wire which converts electrical energy into:

   a) heat and light
   b) heat.

3. You are given 3 similar bars of metal.
   Two of these are magnets and the third one is iron.
   Briefly explain how you identify magnets and iron.

4. You have dropped a sewing needle in a rubbish heap.
   You then try to look for it without success.
   Briefly explain how you can easily find it.
   Remember a needle is made of steel.

5. _____ poles of magnets and _____ poles repel.

6. A coil posseses electromagnetism only when _____

ANSWERS

1. a) electric heater/cooker, kettle etc.
   b) electric light bulb.

2. a) filament
   b) element.

3. Two bars are magnets if the same end or pole of one bar attracts one end and repels the other end of the second bar.

   The metal bar is iron if both its ends are attracted by the same pole of a magnet.

4. A magnet attracts steel objects.
   Since the needle is made of steel I will move the magnet in the heap and this magnet will find the needle for me.

5. Unlike, like.

6. An electric current passes through it.

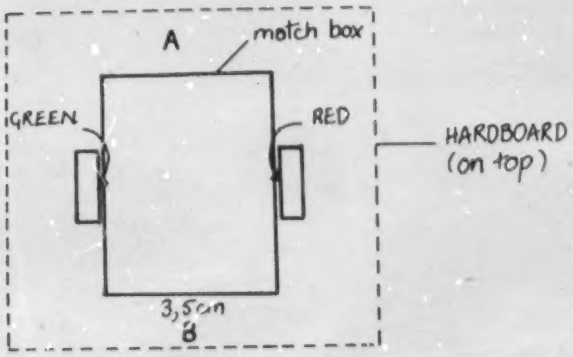
EXPERIMENT 3: A WAY OF MAKING FORCES VISIBLE

Provide the apparatus as per S.G.
Let students carry out the experiment.
You are strongly advised to try this experiment yourself before hand so that you can offer needed assistance during the lesson.
Carefully done, the patterns are clear, definite and different.
The secret lies in tapping and sprinkling the correct amount of iron fillings.

An alternative experiment could be:

You will need:

a matchbox
magnets
a piece of stiff paper (preferably white).



Place a match box flat on the table.
Put magnets in such a way that they rest against the sides of the box.
Place a piece of stiff paper on top of the box.
Sprinkle iron filings on the paper.
Hold the paper in position.
Tap gently points A and B.
A definite pattern should emerge.
Repeat the experiment using like poles.

MAGNETIC FIELDS OF LIKE AND UNLIKE POLES

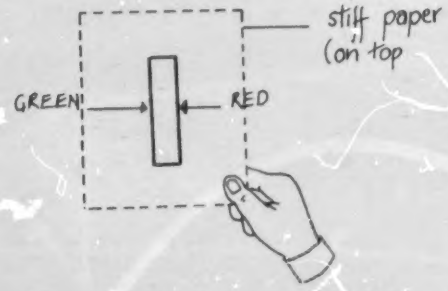
Page 14

This is a graphical representation of the fields produced in Experiment 3.
The magnetic field which is emphasisedis that which exists between the poles.
However, it is important for pupils to realise that each magnet is surrounded by a magnetic field which is 3-dimensional. What we see is a sectional part of the field in one plane .

You may ask your students to carry out the following experiment to show the field due to a magnet.

You will need:

stiff paper
iron filings
a magnet.



Place a magnet on a table as shown in the diagram above.
Rest the paper on the magnet.
Hold it in position and with the other hand sprinle iron filinns on the paper.
Tap the paper gently.
A clear pattern of the magnetic field can easily be seen.
Stress to the students that it is these lines of force which are responsible for attraction and repulsion of adjacent unlike and like poles of magnets.

EXERCISE 3: MAGNETIC FIELDS

Page 14

1. a) How would you find out which poles are like poles given two small magnets whose poles are not marked.
   b) Using the answer to (a) as your starting point, can you tell which poles (N or S) these are? Briefly explain.

2. Do magnetic lines of force exist?
   Briefly explain how you would show that they really exist.

3. Draw diagrams to show the magnetic field due to:

   a) two like poles near each other.
   b) two unlike poles near each other.

ANSWERS

1. a) Like poles repel. If I bring two poles near each other and they repel each other then I know that they are like poles.
   b) No, because the poles may either be both South or both North poles.

2. Yes.
   Magnetic lines of force can be shown by sprinkling some iron filings between magnets. These iron filings will map out the magnetic field consisting of lines of force.

3. See text.

WHAT IS A "SOUTH POLE" AND A "NORTH POLE"?

The syllabus does not ask for a detailed investigation of magnetic fields and so we have only defined the poles in terms of like and unlike. But, if the class asks how did the 'north' and 'south' pole names come about it can do no harm to talk briefly about the earth's magnetic field and compasses.

The "north" pole is, of course, the north seeking pole, i.e. if a needle or nail is magnetised and suspended on a piece of thread its "north" pole will point approximately north because there is a "scuth magnetic pole" in the Arctic region. (Remember unlike poles attract.)

You might like to demonstrate this with a magnetised nail (steel nail).

EXPERIMENT 4: EFFECT OF A MAGNETIC FIELD ON A MOVEABLE CONDUCTOR

Page 15

There are two types of motor kits. Some schools have the type of motor kit (type A) like that on page 18 while others have one (type B) like that on Page 19. So check the pupil kits before issuing the pieces of apparatus needed to assemble the experiment shown in the diagram on page 16 in S.G.

N.B.

1. The copper wire should be 20 cm long not 15 cm .
   The copper loop should be mounted to the circuit board.

2. Type A:

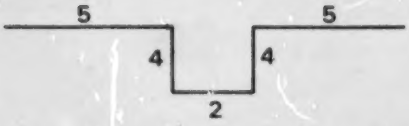
   Split pins are already fitted with rivets.
   The stems of the split pins in the diagram on Page 16 have been cut. There is no need to cut them since the length of the copper wire has been increased.

3. Type B:

   Split pins and pop-rivets are separate.

If emery paper is not provided any rough surface would do to clean the burnt insulation.

After removing the insulation bend the copper wire as in the diagram below.



Then proceed to assemble the apparatus as in the diagram on Page 16.

N.B

I strongly suggest you try this experiment before the lesson so that you are aware of the problems. What I have found very tricky was the contact between the loop and the rivets. This I overcame by turning the split pins sideways slightly until the loop was less free to move.

The loop moves due to the interaction between the magnetic field of the conductor (when electricity flows through the straight base of the loop) and that of the permanent magnet.

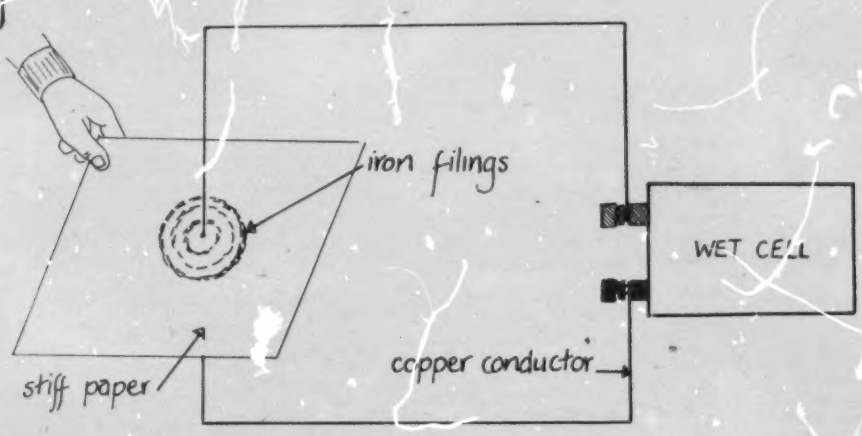
Carry out the following demonstration experiment to show that a magnetic field exists around a straight conductor when electricity flows through it.

P

Fully charge the wet cell the day before for this demonstration.

You will need:

a fully charged cell
a copper conductor (about 50 cm)
a piece of hardboard/stiff paper
iron filings
emery paper/burner.



Remove the insulation from the ends of the copper wire either by emery paper/by heating in a flame. (If you use the flame remember to remove the burnt insulation.)
Using one end of the wire pierce the stiff paper through its centre. Let one student hold the paper horizontally.

Connect the copper ends to the cell and quickly sprinkle some iron filings around the conductor.
Tap the paper if no clear pattern is evident.
Disconnect once the iron filings have formed a pattern.

You can now ask the students the following questions:

What pattern is formed by the iron filings? (A pattern of concentric circles.)
What makes them form this pattern? (Electromagnetism/magnetism due to electricity.)

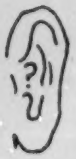
Draw the students' attention to the last paragraph on Page 16 and to the second last paragraph on Page 10 in S.G.

Make sure the students have observed during the experiment what the paragraph says.

Go through the paragraphs on Page 17 and make sure they understand the 'catapult' effect and its application in the electric motor.

ACTIVITY 1: MAKING A MODEL OF AN ELECTRIC MOTOR Page 17

In this activity please make sure that students only remove the enamel on one side of X and likewise on the same side of Y.
Why?
See Discussion below. It is recommended that you try this Activity the day before so that you will be in a better position to help the students. After the Activity go through the explanation on Page 20.



DISCUSSION Page 20

In order for a motor to work (keep moving) with a D.C. supply it is usually necessary to reverse the direction of current every half turn so that the electromagnetic field in the coil is always in opposition to the fixed magnetic field of the magnets.

However, in this model the current is not reversed, but instead is allowed to flow for only one half of each revolution. This is achieved by rubbing off the enamel from the ends of the coil with a knife or "emery" paper but only on one side of the input wire X, and likewise on the same side of the output wire Y. This means that the battery is only connected for half of the time and inertia of the coil has to carry it through the other half of the cycle.

(Inertia is the property of matter by which it remains in a state of rest or, if it is in motion, continues moving in the same direction.)

Note, that if all the enamel is removed completely from both ends of the coil it will not rotate but only vibrate.

EXERCISE 4(a): HOW THE ELECTRIC MOTOR WORKS

When the circuit is completed current flows through the coil and this results in the turning of the coil since it is in a magnetic field. The current flows through the coil for half of the revolution only since the enamel is only removed on one side.

During the second half of the revolution the coil will continue to rotate on its own until the current flows through the coil again. This process is repeated and the coil keeps on rotating as long as the circuit is complete.

ACTIVITY 2: LOOKING AT A FACTORY-MADE MOTOR Page 20

If your school has not been supplied with small electric motors in the kit I suggest you use the electric motor you used in Unit B. This will mean that this Activity will be a demonstration.

Go through the characteristics on Page 21 after the students have identified the components of the motor. Tie up characteristic 4 with the model in Activity 1.

EXERCISE 4(b): ELECTRIC MOTORS Page 21

1. What energy changes take place in the electric motor when it is in action?

2. Draw the diagram of your model. Briefly explain how it works.

3. What will be the effect of adding a second cell to the circuit?

4. Why is it necessary to disconnect the battery soon after use?

5. What are the important parts of a simple electric motor?

6. Give two examples where electric motors are used.

7. What is the advantage of using more than one coil in an electric motor?

8. Why should a commutator have gaps?
Explain briefly what would happen to the motor if a commutator had no gaps.

ANSWERS:

1. Electrical ⟶ magnetic ⟶ movement (kinetic).

2. A diagram which is the sum of the last two diagrams in the Activity plus a cell/two.
Explanation comes from ***. Note that the explanation should agree with the direction of current as determined by the way in which the cell is connected.

3. The motor will rotate faster due to an increase in energy supply.

4. The battery should be disconnected quickly lest it runs down.

5. - 8.

From the S.G. and Discussion. Ask students to write down the summary at the top of Page 22.

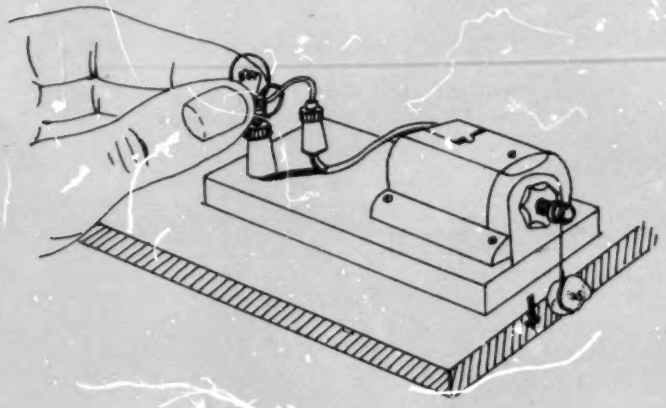
DISCUSSION: ELECTRIC GENERATOR Page 22

An electric generator, e.g. a bicycle generator, produces electricity when it is mechanically moved. It converts mechanical energy to electrical energy.

ACTIVITY 3: GENERATING ELECTRICITY Page 22

This Activity can again be a demonstration one if you do not have electric motor kits for students. Use the electric motor you used in Unit B and follow the method in the S.G. of this Unit.

If students have the kits I suggest that after the Activity you do Experiment 12 in Unit B to emphasise that electricity is generated and can light a bulb.



Draw the students attention to the last paragraph on Page 22 on the difference between a motor and a dynamo.

Go through the historical background information on how Oersted's discovery led to the construction of dynamos.

The second paragraph on Page 23 refers to the generation of electricity at Kariba. The explanation in Unit B is straightforward. But please note that the electricity generated at Kariba is AC not DC like that just produced in Activity 3. The difference between DC and AC will be looked at shortly.

What is important at this point is that water, instead of a hand/stone, is used to work the dynamo which then produces electricity.

The wall chart 'ELECTRICITY FROM WATER' (available from Audio Visual Services, Harare) is a better diagram than that in Unit B. Use this as well for the explanation.

EXERCISE 5: THE DYNAMO Page 23

1. What does a dynamo do? What energy changes take place in a dynamo?
2. What is meant by electromagnetic induction?
3. Write a short paragraph on how electricity is produced at Kariba and how it gets to towns, mines and growth points.

ANSWERS

1 and 2 from text.
3 from Unit B.

ACTIVITY 4: GENERATING DIRECT CURRENT Page 23

This is an extension of Activity 3. It is a straight-forward activity with no problems envisaged. Point out that it is not possible to maintain the pointer at a fixed mark as shown in the graph on Page 24.

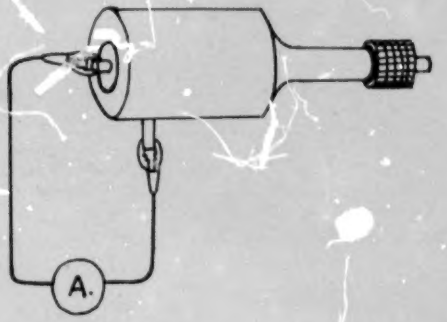
To achieve this one has to rotate the axle steadily. What the students will see is that by rotating the axle faster the pointer will not drop to 0 but will flicker to and fro about a certain graduation.

ALTERNATING CURRENT (AC) Page 24

This is a demonstration Activity since you only have one bicycle generator. It may be more fun if your students can provide bicycle generators. So, ask them to bring some if they have any. The dynamo is quite robust so if some students have bicycles with dynamos these can be removed, used in class and these can easily be fixed to bicycles after use.

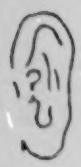
For the demonstration you will need:

a bicycle dynamo
2 leads
an ammeter.



Assemble the apparatus as in the diagram above.
Take your students in small groups (if you only have one dynamo) and let one of them rotate the dynamo first slowly and then fast while others observe the pointer.

Let them note what happens in each case and then do the same to the next group. Repeat this until all the students have made their observations. Then proceed to discuss observations made during the Activity.



DISCUSSION Page 24

When the dynamo was rotated slowly the pointer moved from 0 to one side, back to 0 then to the other side and back to 0.

This cycle was repeated as long as the rotation was slow. When the dynamo was rotated very fast the pointer remained stationary or just vibrated about the 0 mark. The reason is that the current was changing direction faster than the pointer can follow hence it remained stationary.

To illustrate this point, here is another Activity you could do with your students.

Make your students sit upright facing you. Then tell them to turn their necks and look to the right and then to the left:
R-i-g-h-t L-e-f-t (slowly).
Repeat this 3 or 4 times.
Then repeat the Activity faster - finally do it very fast.

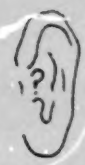
It will be noticed that they can only shake their heads in order to obey the last order

This raises the question:

How can we measure alternating current (AC) since our ammeter registers 0?

The ammeter used in this Activity measures DC only not AC.
To measure AC we need an ammeter designed to measure it.
(DC is measured by a moving-coil ammeter and AC is usually measured by a moving-iron ammeter. The moving iron ammeter may be an attraction type or a repulsion type.)
(It is not necessary for pupils to be taught these details, they are for your information.)

Go through the graphical representation of AC and emphasise the fact that the electricity supplied by Kariba travels to and fro 50 c/s. (Note 1 c/s (cycle per second) = 1 Hertz (Hz)).



DISCUSSION Page 25

The p.d. that drives DC through a conductor is direct and that which drives AC is alternating. This can be verified by replacing an ammeter with a voltmeter in the DC and AC generators.

EXERCISE 6: DIRECT AND ALTERNATING CURRENTS Page 25

1. Direct current (DC) is that electric current which _____ in _____ _____ only. A _____ supplies DC.

2. a) Alternating current (AC) is that current which changes _____ at _____ _____.

   b) Draw a graph that represents one cycle.

   c) The electricity supplied by Kariba travels to and fro ____ times per _____

ANSWERS

From the text.

APPLICATION OF THE ELECTRIC MOTOR Page 25

Electric motors are extensively used in everyday life (see Page 17). The recently introduced use of electric motors is that on our National Railways. This goes to emphasise that science is at the service of man. Apart from the advantages (economic, comfortable, less noisy, non-smoky, our own source of energy) of using electric trains emphasis should be laid on the safety aspect when using high voltages and currents like those used on our railway network.

Go through the pictures on Pages 26 and 27 pointing out the dangers the children in these pictures are exposed to. Playing near the railway line or crossing the railway line in front of an oncoming train is dangerous because the train is very fast and silent. Touching electrical wires results in death/severe shock due to shorting the circuits. Come back to this safety aspect after going through Pages 36 to 39.

N.B.

Because of the lay-out of the pages, each of the statements above the pictures on Pages 26 and 27 is not complete e.g. the statement above the first picture appears to encourage students so play near the electrified field.

To avoid this possible confusion, each statement must be PRECEDED BY: YOUR LIFE IS IN DANGER IF YOU (play anywhere near the electrified areas, touch broken overhead lines etc.).

Please emphasise this. The children can even write it in the S.G.

EXERCISE 7: ELECTRIC TRAINS Page 26

1. Write down two more advantages, apart from the one given in the text, why Zimbabwe has decided to use electric trains.

2. Write a short paragraph on why you should be very careful when you are near an electrified railway line.

ANSWERS

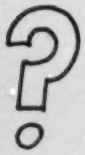
1. (a) Electric trains are quiet and so do not pollute the environment by their noise.
   (b) Because electric trains do not use fuel such as coal or oil they do not produce smoke which pollutes the air.
   (c) Electricity is our own energy source and comes from the hydro-electric power station at Kariba or the coal burning station at Hwange.

2. Students can use the pictures for this paragraph.
   The important message conveyed should be that of danger when playing near a railway line, touching the power wire.

ANSWERS TO "HOW MUCH DO YOU KNOW?"

Page 27

Students should write the whole sentence filling in the blank spaces where appropriate.



1. Work done, newton metre (Nm) joules (J).
2. Work, energy.
3. Work done, time, one second.
4. Volts/p.d., current, watt J/s (joules per second).
5. p.d.
6. Current $= \frac{\text{watts}}{\text{volts}}$

   $= \frac{24}{12}$

   $= \underline{2A}$
7. Heating, elements, heat, filaments, heat, light.
8. N (north, S (south), repel, attract.
9. Attracts, fall/drop, magnetism, electromagnet.
10. Magnetic field, force, unlike.
11. Move, direction, current/electricity, reversed.
12. Electrical, mechanical/kinetic.
13. Mechanical/kinetic, electrical.
14. One direction, reverses/changes, direction.
15. 50, second.
16. Voltages, currents.

HOUSEHOLD ELECTRICITY

Page 29

If power lines pass through your area it is recommended that you take the students there if it is near or ask them, when next they come across power lines to note:

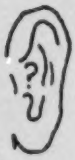
1. the thickness of the cables.
2. where the cables are fixed to posts (insulators).
3. whether tree branches come into contact with cables (NO).
4. whether the cables are covered with insulation (usually not).
5. whether the wire/s at the very top is/are tied to clay/to the metal pylons. (If wooden posts are used - they should note that the top wire is connected to another wire (fixed to post) which leads to the ground (Earth wire/s). If metal pylons are used - like those from Kariba - the top wires are connected to the pylons fixed to the ground.)

6. the danger sign.

7. whether the cables are coloured and if so what their colours are. (Overhead power lines are usually bare.)

Let your students read about "How electricity gets to homes". Make sure they understand these key words:

Mains, substation, live and neutral and their potentials, fuse-box, lighting and power circuits.



DISCUSSION Page 30

See last paragraph on Page 30. The important points to emphasise are fuses protect the system against fire, overload etc. and protect the user against electric shock.

EXERCISE 8: HOUSEHOLD ELECTRICITY Page 30

1. Draw and label the diagram of a Household Circuit.

2. Why is it not advisable to touch uninsulated wires in the household circuits?

3. Which wire carries electricity into the house? What is its potential?

4. What is the function of the neutral wire? What is its potential?

5. Which of the two circuits in the house carries a bigger current? Give a reason for your answer.

6. A lighting circuit is protected by a 5A fuse.
An electric kettle marked 2300W230V is connected to the circuit at the bulb socket.

   a) What current should flow through the circuit when you switch on?
   b) What is likely to happen to the fuse? Give a reason.
   c) This circuit is said to be _____ because the kettle connected to it draws _____ from the circuit than the circuit normally supplies.

ANSWERS

1. As per diagram on Page 30.

2. Touching the wires is dangerous because high voltages can force a current through the body and this can cause severe electric shocks or even kill.

3. The live wire, 230V.

4. The neutral wire returns the electricity back to substation and it is at 0 potential.

5. The power circuit, because power appliances use big currents when they are in operation.

6. a) Current $= \frac{\text{Watts}}{\text{Volts}}$

$= \frac{2\ 300}{230}$

$= \underline{10A}$

b) The fuse will blow because the kettle draws more current than the circuit can supply.

c) Overloaded, more current.

LIGHTING CIRCUIT Page 31.

Error:

The energy flow comes through the 'live' wire and not by both the live and the neutral as in the diagram. The arrow in the neutral should point in the other direction. Ask students to correct this.

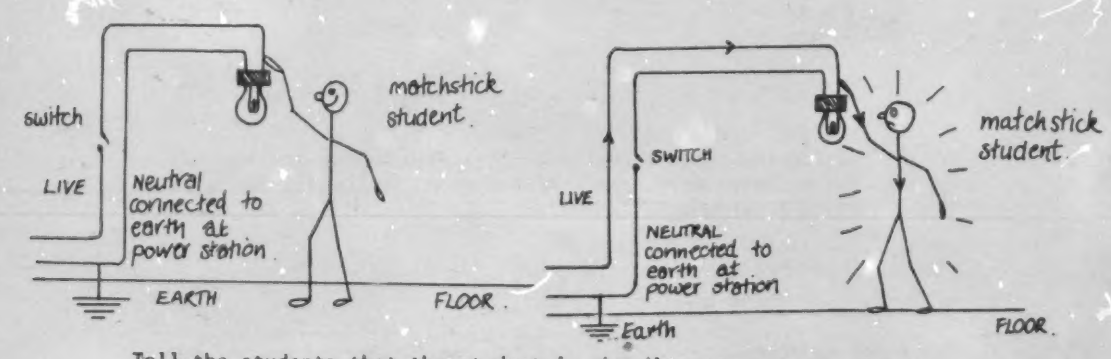
Students should note that:

N.B.

a) The circuit is protected by a 5A fuse which is connected to the live wire.
b) Bulbs are connected in parallel. If your school is supplied with electricity you can show them that bulbs are in a parallel circuit by removing one bulb and then switch on. The rest should light. This shows that each bulb in this circuit works quite independent of the others.
c) Switches are always connected in the live wire.

DISCUSSION Page 31

For this discussion draw the circuit with a match-stick student touching the live wire thus:



Tell the students that the student in the diagram wants to remove the bulb which has blown. The student accidentally touches the live wire. What will happen in each case?

The switch wrongly placed in the neutral is no protection at all. The live wire is still 'live' i.e. it carries electricity up to the bulb although the circuit is broken at the switch. Since the live wire is still 'live' a student touching it accidentally gets an electric shock because a high voltage (230V) will drive a current through the student's body.

At this voltage a person becomes a conductor. Thus when repairs/ adjustments are made to the wiring of a circuit, it is wise to switch off at the main switch thereby isolating the circuit from the mains, and not to depend on the supposedly correct wiring of a lighting switch.

POWER CIRCUIT

Page 32

The ring-main circuit diagram is more complex than the lighting circuit. Emphasise that each of the three wires in the ring-main goes right round the house and that each wire is connected to a power point. At this point the students do not know the function of the Earth connection. Tell them that its use will follow later.

N.B.

The reason for a ring main is that thinner wire can be used for power circuits since the energy can flow in both directions around the ring to the power point.

EXERCISE 9: LIGHTING AND POWER CIRCUITS

Page 33

1. a) Draw and label the diagram of the lighting circuit.
   b) How are light bulbs connected in this circuit?
      What is the advantage of connecting them in this way?
   c) To which wire are the fuse and the switch connected?

2. a) Draw and label the power circuit.
   b) Where would you find the fuses which protect the appliances connected to the ring-main?
   c) If one of the appliances is out of order would it affect other appliances also connected to the ring-main?
      Give a reason for your answer.

3. Write the summary on the ring-main in your notebooks.

ANSWERS

1. a) Text.
   b) In parallel.
      The advantage is that when one bulb blows other bulbs will not be affected.
   c) To the live.

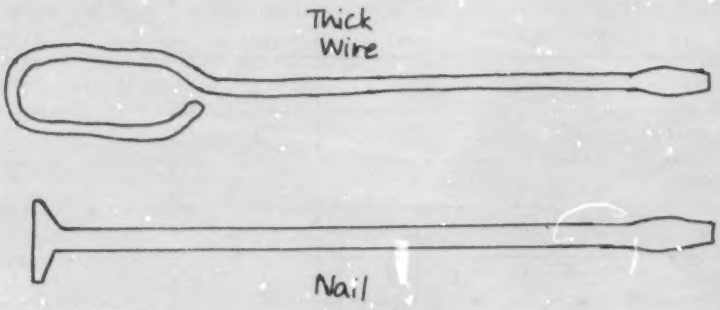
2. a) Text.
   b) Inside the plugs connecting the appliances to the ring-main.
   c) No, because each appliance connected to the ring-main works quite independent of others.

3. Text.

ACTIVITY 5: WIRING A PLUG

Page 33

There are no screw drivers provided for connecting the power cable to the plug. Ask your students to bring one (if available) or ask them to make one out of a thick wire or big nail. If students can't get either of these then ask them to bring a knife instead.



ERROR:

Note that the discussion symbol was placed wrongly. Ignore it.

The cable is thick because it is intended to carry large currents which deliver energy to power appliances. The insulator protects the user against electric shock and prevents shorting the circuit.

Let students proceed to connect the cable to the plug using the instructions in the S.G. Emphasise the importance of the colour code in ensuring the correct connections. The old code is included because some old electrical appliances are still in use today.

NOTES Page 35

Write the heading:
THE COLOUR CODE AND WIRING A POWER PLUG on the board. Then tell the students to write the table on Page 34 and draw the diagram on Page 35 in their notebooks.

CHOOSING THE CORRECT FUSE Page 35

Every power appliance is protected by a fuse of suitable rating which is inside the plug. Since the power rating and the p.d. are usually marked somewhere on the appliance , it is easy to calculate the current and hence enables one to choose/buy a fuse of suitable rating needed to replace a blown fuse. The diagram on Page 36 shows the method of doing this.

EXERCISE 10: CHOOSING THE CORRECT FUSE Page 36

1. Draw the first diagram on page 36 on choosing the correct fuse

2. The Table below is incomplete. From the information provided carry out the necessary calculations to fill in the blank spaces.

APPLIANCE	POWER (W)	VOLTAGE (V)	CURRENT (A)	CORRECT FUSE (1,2,5,13A)
Electric cooker	2 400	230		
Electric heater		230	12	
Radio		230	0,2	
Television	150	230		
Light bulb	100	230		
Car headlamp		12	4	
Electric iron		230	3	

ANSWERS

1. Text.

2. 10,4A 13A
   2760 13A
   46W 1A
   0,7A 1A
   0,4A 1A
   48W 5A
   690W 5A

FUNCTION OF EARTH WIRE Page 36

Let your students read silently the first one and a half pages. Briefly go through what the students have read about and emphasise that by touching the live wire the boy completes the circuit resulting in him experiencing severe electric shocks. (This is similar to the matchstick boy we met earlier on. At this point you may refer to the dangers associated with the electrified railway line.)

Allow the students to read the next two pages. Then go through these pages with them explaining how the earth wire protects the user of an appliance in the event of a fault. Emphasise the role of earthing and fusing. Note that the fuse is actually in the plug.

As a point of interest you may ask your students:
What would the boy in diagram B experience if he were wearing a pair of shoes with thick rubber sole?

Rubber is an insulator so the boy will not get an electric shock. Point out that the shock is more severe when the hands and the bare feet are wet. When these are wet you becomes a better conductor allowing a bigger current (which delivers more energy) to pass through the body.

N.B.

Page reference is missing. It should be: See Page 30.

DISCUSSION Page 39

Electric light bulbs are not earthed because their metal parts are not normally touched by hand.

EXERCISE 11: USE OF EARTHING IN POWER CIRCUITS Page 39

1. a) Which circuit is always earthed?
   b) Who is protected by earthing an appliance?
   c) Briefly explain how earthing an appliance offers this protection.

2. Draw diagrams B and C on earthing.
   To save time you may draw a match-stick student in each diagram to represent a boy/girl.

3. Why are light bulbs not earthed?

4. Why is the shock more severe when the hands and bare feet are wet?

5. A bird sits on the live wire of the Kariba power line.
   Will the bird get a very severe shock?
   Briefly explain your answer.

ANSWERS

1. a) Power circuit.
   b) The user of the appliance.
   c) The metal casing of an appliance becomes live when a fault develops in the appliance. A person handling this appliance does not get an electric shock. This is because a large current will flow back to the substation through the earth wire which is a better conductor of electricity than a person's body. The large current flowing through the circuit will cause the fuse in the appliance to blow and this cuts off the electrical supply to the appliance.

2. Text.

3. Light bulbs are not earthed because their metal parts are not normally touched by hand.

4. Wet hands and feet are a better conductor of electricity than dry ones. Thus a larger current, delivering more energy, will pass through the body causing a more severe electric shock.

5. No.
   This is because the bird does not complete the circuit by sitting on the live wire only.

PAYING FOR THE ELECTRICAL ENERGY Page 40

Let the students go through the first 4 paragraphs and then explain the units:- kilowatt and kilowatt-hour.

DISCUSSION Page 40

1 kW = 1 000 J/s

1 h = 60 x 60 s
= 3 600 s.

Therefore number of joules in kWh = 1 000 x 3 600

= 3 600 000

So a large quantity of energy is delivered in one hour!

Then go through the rest of this section and emphasise the fact that the time required to consume a unit depends upon the power of the appliance as shown in the diagram at the bottom of the page.

EXPERIMENT 5: FINDING THE POWER OF A TORCH BULB Page 42

Provide your students with the apparatus required for this experiment. Let them carry out the experiment and record their readings.

EXERCISE 12 Page 42

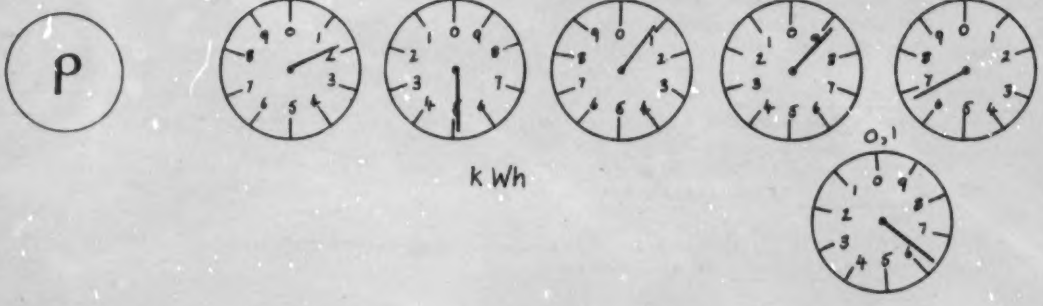
As per S.G. Answers as per students results.

DISCUSSION Page 42

Results should not be the same because:

1. The cells do not supply the same currents.
2. The bulbs have different resistances and hence the p.d.s across the bulbs are different.

TAKING METER READINGS Page 42



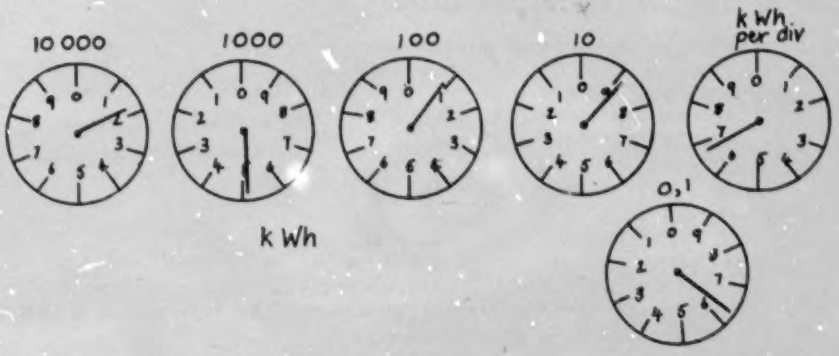
Make six dial faces (numbered from 0-9), with a moveable pointer, from cardboard/manilla as in the diagram above. Take note of the numbering on each dial face.

(A) TAKING READINGS FROM DIGITAL METER

Taking readings from this meter is very simple as illustrated in the given examples. Knowing two readings one can calculate the consumption by subtraction. Modern meters are digital.

(B) TAKING READINGS FROM A DIAL METER

Taking readings from this meter is rather difficult.
In order to give your students practice in reading the meter you carry out the following Activity.

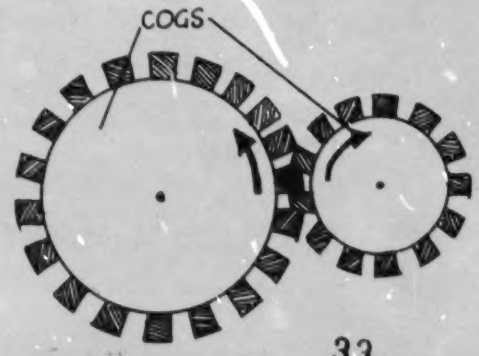


Stick the dial faces onto the board as in the diagram above.
Set the pointers as in the diagram.
When taking the reading the digits (numbers) are read successively starting with the units:
On each dial you should always take the nearest whole number below the pointer position.

Using this rule the reading shown in the diagram above is 15086 - the reading on the tenths dial is ignored as its function is mainly to test the meter.

N. B.

The clockwise and anticlockwise numbering on the dials is due to the fact that the cogs inside the meter (to which poincers are connected) are arranged in such a way that as one cog moves in one direction the next one moves in the opposite direction.



Change the positions of the pointers and ask the students to take the reading. This can be repeated until students master the method of taking the readings.

You could give a written exercise, say about 5 readings which can be marked by students. This will help you to know which students need help.

COST OF ELECTRICAL ENERGY CONSUMED Page 43

Once students know how to calculate the units consumed and the cost/unit it is easy to work out the total cost of energy consumed.

EXERCISE 13: COST OF ELECTRICITY Page 43

1. What is the unit of electrical energy?

2. You have two 40W bulbs and two 60W bulbs in your house. How much will it cost you to keep these alight for 10 hours a day if the cost of a unit is 4 cents?

3. An electric cooker is rated at 250V, 3kW.

   a) What current will pass through the circuit?
   b) How long will it take the cooker to consume 1 unit (i.e. 1 kilowatt hour of electricity?)?
   c) If the cost of a unit of electricity is 4 cents, how much will it cost to use the cooker for three hours?

ANSWERS

1. The unit is a kWh.

2. Total power used = 2 x 40W plus 2 x 60W = 0,2 kW
   ∴ total units (kWh) used in 10h = 0,2 x 10
   = 2
   ∴ total cost = 2 x 4c
   = 8 cents.

3. a) Current passing through = 3 000 ÷ 250
   = 12A

   b) Time taken to consume 1 unit = $\frac{1 \text{ kWh}}{3 \text{ kW}}$
   = 20 minutes

   c) Cost for using the cooker for 3 hours = 3 x 3 x 4c
   = 36 cents

N.B. Note, if you feel more numerical examples are needed give them your own questions.

HOW MUCH DO YOU KNOW?

Page 44

Correction:

Tell students to cross out No. 1 in S.G. and write in ink the following No. 1.

1. It is dangerous to touch an _____ conductor of a household circuit because a _____ (230V) is capable of forcing a _____ _____ through one's body resulting in one experiencing an _____ _____.
   One can even be _____ if the _____ is large enough.

ANSWERS

1. Uninsulated, high voltage, [illegible]urrent, electric shock, killed/electrocuted, curre[illegible]
2. Live, neutral, earth/ground, zero/0.
3. Fusebox, electricity/supply, current, meter, power.
4. Fuse, melts/blows, current.
5. Live.
6. Live, neutral, green-yellow.
7. (Electric) shock.
8. kWh, 1 000W, one hour.
9. Metal.
10. Ring-main.

SUMMARY

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Ask the student to write this in their books.